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ABSTRACT

In order to aid colleges and universities in establishing computing centers or in expanding existing ones, the following recommendations are made--(1) great care should be taken in the selection of a director, (2) the budget of the center must be given a high priority, (3) equipment should be carefully selected, (4) some key staff members should be selected prior to the installation of the computer, and (5) an outside advisor should be sought. The following topics are discussed--services rendered by the computing center, the computer equipment, space and location requirements, staff requirements, and administration and financing. (NI)

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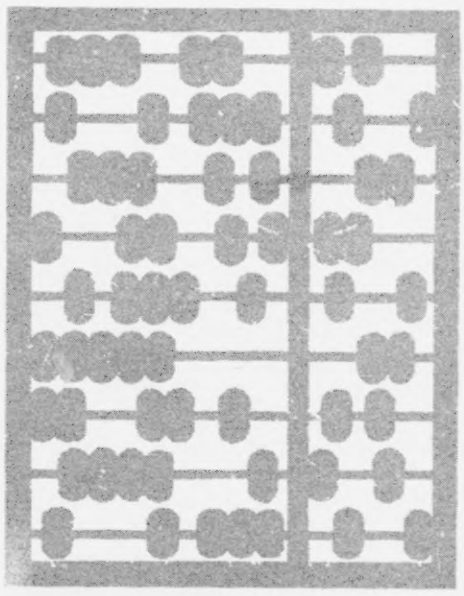

GUIDELINES FOR PLANNING COMPUTER CENTERS IN UNIVERSITIES AND COLLEGES

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SOUTHERN REGIONAL EDUCATION BOARD
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Computers have enabled states and their higher institutions to solve or to make manageable complex problems associated with the planning, development and conduct of higher education. Administrators, teachers, scientists and engineers utilize a wide range of computer techniques to cope with the enormous detail of research and administrative records.

Increasingly, computers are being used in imaginative ways to present effective instruction to students. University computer centers are serving communities by analyzing complex data and producing information vital to the economy of the states in the region.

The capital investment in equipment for computer centers is large. States and their higher institutions need to determine the kinds of jobs they want computer centers to perform, and then plan carefully the acquisition of equipment that best can do these jobs.

This publication has been prepared by a cross-section of the region's leading computer center directors. It provides in brief fashion basic information designed to be of help in planning new computer centers or expanding present centers. The Southern Regional Education Board hopes that this publication will be of constructive assistance to further discussion and development of ideas about use of computer centers for raising the quality of higher education in the South.

Winfred L. Godwin
Director
Southern Regional Education Board

ACKNOWLEDGEMENTS

This booklet presents some general guidelines for establishing computing centers in colleges and universities. Although not intended to be an exhaustive treatise, it does present some of the major problems and suggest a rationale for the installation of expensive computing equipment in an educational setting.

Its publication is the result of a project of the Advisory Committee on Computers and Computer Science of the Southern Regional Education Board. Dr. William F. Atchison, Director of the Rich Electronic Computer Center, Georgia Institute of Technology, is chairman of this committee; and Dr. E. P. Miles, Jr., Director, Computing Center, Florida State University, was chairman of the editorial subcommittee. Other members of the subcommittee were Dr. Atchison; Dr. Werner C. Rheinboldt, Director of the Computer Science Center, University of Maryland; and Dr. Darrell R. Shreve, Director of the Computing Center, North Carolina State College. Dr. Redding Sugg, chairman-elect of the Department of English, Memphis State University, has edited the material for the press.

Members of the Advisory Committee at the time this work was undertaken made significant contributions to the booklet. These include Dr. John Folger, Dean of the Graduate School, Florida State University; Dr. Elliott I. Organick, Director of the Computing and Data Processing Center, University of Houston; Dr. William Orthwein, Director of the Computing Center, University of Oklahoma; and Dr. David M. Young, Jr., Director of the Computing Center, University of Texas. Dr. James H. Bash, Programs Associate of the Southern Regional Education Board, also advised the subcommitee.

Helpful suggestions and criticisms have been received from Mr. Robert Smith, Director of the Data Processing Center, Texas Agricultural and Mechanical College; Dr. Albert Drake, Consulting Statistician to the School of Agriculture, Auburn University; and Dr. John C. Currie, Professor of Mathematics, Georgia Institute of Technology.

William L. Bowden
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Electronic computers are a very recent addition to modern life. It is not even twenty years ago that the experimental forerunners of present day computers were designed, and it is only about a dozen years since the first commercially available computer was offered on the market. In the meantime, the number of computers has risen to more than 15,500; there is hardly any place in modern life that has not felt their influence. In fact, the impact of electronic digital computers has been so strong that it has been compared with the impact of the first industrial revolution on Western civilization.

While computers and computer applications are of increasing importance, there is at the same time a serious shortage everywhere in industry, in government, and in academic institutions of personnel trained to program and use computers. There is an even greater gap in personnel trained to make proper and effective use of computers in the solution of problems and to develop the emerging academic-technical field of computer science. In addition, there is an acute shortage of management personnel to direct the activities of computing facilities.

This shortage of computing personnel must be faced by the educational system. But computers pose for education not only the problem of developing computer scientists and users but also a variety of opportunities in the whole range of academic instruction and research. They are changing the approaches to many disciplines, they open new areas of research, they provide more information about complex phenomena, they help solve problems which would otherwise be unmanageable.

In the past year, many institutions of higher learning have become aware of the problems and opportunities which the computers present. The number of computer installations at colleges and universities increased markedly. There are now about 200 computing centers at U. S. colleges and universities with equipment ranging in size and cost from the smallest to the largest available. The general tendency is to integrate the use of computers into the educational framework and to establish special and new curricula for students who wish to enter the computer field directly. Wherever a computer has been introduced, its use for instructional, research, and administrative purposes has expanded rapidly and usually beyond all expectation.

The present booklet is meant to help colleges and universities in establishing computing centers or in expanding existing ones. The major recommendations may be summarized as follows:

1. *Director.* Great care should be taken in selecting an experienced director who will command the respect of colleagues in all fields. He should be able to promote computer use in research, instruction, and administration wherever appropriate. He should report to an official of the university with major academic responsibilities.

2. *Budget.* The center must be given high priority in the budget of the institution in view of the extraordinary initial costs and growth rates for university computing requirements.

3. *Selection of equipment.* Equipment must be carefully selected to meet not only initial needs but to be easily expanded to meet future needs. Other important consid-

erations are the adequacy of the manufacturer's maintenance services, the suitability of the computer program library, and the ability of the equipment to perform expeditiously the *entire* computation job from initial input to final output.

4. *Selection of staff.* Some key staff members should be selected prior to installing the computer to insure the existence and useability of an appropriate computer library for doing the jobs on hand when the equipment is installed. Staff for maintenance and development of a computer library are essential.

5. *Advice.* Consultation and advice from disinterested computer scientists should be sought. Consultants should have had an opportunity to acquaint themselves with the needs and resources of the institution.

SERVICES RENDERED BY THE UNIVERSITY COMPUTING CENTER

The computing center of a major university can serve not only the full range of academic departments but also provide the staff and laboratory facilities for the emerging discipline of computer science, which is concerned with the training of computer specialists of various types.

As an illustration of the diverse fields which a computing center may serve, the active users list of one university computing center now includes over 200 projects distributed over the fields of biology, business, chemistry, economics, engineering science, education, physical education, English, food and nutrition, geology, government, home economics, library science, mathematics, meteorology, music, oceanography, physics, psychology, social welfare, sociology and statistics. Other universities having schools of agriculture, law, or medicine have numerous computing projects from those fields. People in any discipline can use a computing center to advantage as an aid in

processing the current literature of their field for purposes of information storage and retrieval.

In many universities, major portions of the bookkeeping and payroll activities of the business office and the registration procedures and student record keeping of the registrar are being carried out with the aid of computers. They are used, for example, in determining and printing student schedules and in printing class cards. The result is a great saving of faculty and staff time once required for tedious clerical work at registration time.

The new discipline, usually called 'computer science', which the existence of a center with adequate staff enables the university to offer has not been precisely defined. It is, however, interdisciplinary in nature and involves such topics as the theory and application of computer programming, problem-solving techniques, methods of applying computers to various fields, logic and algorithms, information storage and retrieval, automata theory, design of computers, and information theory. Several institutions already have computer science departments or other departments which embrace part of this material. Any school should include in its long-term planning the possibility of offering this interdisciplinary subject of computer science whether it does so in a separate computer science department or through other departments of the institute.

In addition to serving the several academic disciplines, to facilitating administrative operations, and to providing the opportunity to offer training in computer science, a computing center provides a number of important fringe benefits.

It helps, for example, in the procurement of able students for fields in which computing has become a signifi-

cant element. Students interested in such fields are likely to inquire not only whether a school has a computer but what kind of computer and whether it is used in instruction; and they may even want to know what courses make use of the computer.

The history of computing on college campuses shows that students profit in many ways from access to a computer. Intelligent students of business administration supplement their training by writing business game programs. Physics and engineering students write programs for nuclear reactor operations and for meeting design requirements for structures. Students in programming courses write new assembly and compiler programs, and some students even write programs to compose music on a computer. Although their work may be amateurish, students use computers to exercise creative intelligence, to develop planning of work as a habit, to analyze theories—studying the complexities and difficulties and putting them to work.

As the availability of a computer may attract able students, it certainly attracts and helps to hold research men and ultimately expedites and broadens the scope of research. For it drastically reduces the tedium of large volumes of computation which in the absence of a computer may delay the completion of research or even prohibit developments in theory and application. The high-speed computer lifts this burden from the man in re-

search, thus not only increasing his effective life but also permitting him to do research of greater magnitude by solving in a matter of days problems which would have been disregarded twenty years ago as too demanding and time-consuming to permit investigation.

The wide variety of non-numeric applications of computers which are now possible makes them effective in an ever increasing number of fields. The digital computer, for instance, is now recognized as a device for manipulating symbols of any kind, in any way. Research in mathematical logic has already shown that machines of this kind have almost universal capabilities in executing algorithmic processes.

Another fringe benefit results from the fact that the staff of a computing center affects not only the work of individuals but also that of groups. In discussions with research men, computing staffs occasionally point up a community of interest among men in different disciplines, where the knowledge of one supplements that of another, where the method of one complements the method of another, where duplication of effort on small problems can be changed to effective contribution on large problems. A habit of cooperation and communication is established for some of the faculty and results in greater interdisciplinary understanding.

Success encourages continued effort in research, and the academic atmosphere is improved. As this community of accomplishment develops, positions on the faculty become more desirable to competent men. In teaching as well as in research, the effect is apparent. For men with a creative interest in teaching can use a computer, for example, in preparing problems for assignment wherein they can provide each student with unique data and have correct solutions to all problems available with little extra effort. More individualized instruction can thus be provided.

THE COMPUTER EQUIPMENT AND ITS PROGRAMMING SUPPORT

The selection of appropriate computer equipment for an educational institution depends on a variety of factors, such as the particular needs of the institution, the type and extent of use that is anticipated for the computer, and —most important—the financial resources and personnel that are available. Since these factors vary greatly from institution to institution, few recommendations can be made applicable to all situations. It is safe to say, however, that the equipment should be chosen only after consultation with computer experts familiar with these factors and not solely on the basis of discussion with the sales representatives of computer manufacturers.

This section provides general information to aid in the understanding of computer terminology and stresses points that anyone should consider in selecting computer equipment. One of the most important of the latter is the availability of an appropriate computer program library,

called 'software' in contrast to the computer equipment itself which is often called the 'hardware.' Experience has shown that the software support of a specific piece of hardware is frequently as important as a variety of new ideas in the hardware design.

THE HARDWARE

The term 'hardware,' as suggested above, refers to the electrical and mechanical devices used in the machine-processing of information. Except for small computers, a modern computer system rarely consists of only one physical unit. Instead, a variety of units is usually involved, each of which is interconnected by special cables and serves a special purpose. The heart of such a system is often called the 'main frame,' which is also the particular part of the computer specified by the model number, e. g., 'The Wonderful 3001'. The main frame includes (a) the control unit, which serves to direct the overall operation, (b) the arthmetic unit, which performs addition, subtraction, multiplication, etc., (c) the main memory unit, in which data and instructions are recorded and, (d) the operator's console. In addition, every computer system has to have at least one set of input/output devices, such as a card reader and a card punch, for communication with the outside world.

Although the computer elements mentioned so far comprise the basic part of a computer system, they rarely constitute the computer in its entirety. For practically every system now on the market, a variety of units can be attached to expand its capabilities. In other words, most modern computer systems can be expanded to serve the growing needs of their users. Extra memory modules to increase the capacity of the main memory unit may be added. Special operator consoles (often called 'inquiry stations') or additional input/output devices are available.

On occasion, a second central processing unit may be needed and available for parallel operation.

Among the units most frequently added are auxiliary memory devices, such as magnetic tapes, which therefore deserve special mention. The main memory unit of a computer is used for storage of the instructions about to be executed and for the corresponding sets of data. When new information enters the main memory, part or all of what was in the memory is erased and replaced by the new information. The computer's ability to process problems involving many steps and/or large amounts of data depends on the size of the memory. Auxiliary memory devices are therefore desirable to store excess information to be used only infrequently in the program.

At the same time, certain types of auxiliary memory devices can act as additional input and output units if the stored information can be removed from the unit and handled elsewhere, away from the system. One such auxiliary memory device is the magnetic tape unit, which resembles the well-known tape recorder. Information is stored in the form of magnetic spots on reels of plastic tape coated with a special layer which has specific magnetic properties. Other auxiliary memory units in frequent use are disk storage units, wherein disks with a magnetic coating are arranged much as the records in a coin-operated record player, except that information is

stored in the form of magnetic spots and not in the form of varying grooves. In some models, such disks may be removed for later use. If they are not removable, the information stays with the machine and restricts to some extent the versatility and storage capacity. It should be pointed out, however, that on the machines which have non-removable disks, speedier access to information and greater machine reliability are normally effected.

Information to be processed by a computer first has to be transcribed into a form the machine can read. Depending on the type of input equipment available, this requires special equipment, such as card punches, also called keypunches; perforated paper tape punches; or magnetic tape writers. It is also possible to enter some information directly into the computer via the console of the system, but limited use is made of this procedure because it slows the total operation. While the equipment to perform such transcription is generally not included in the assembly which is referred to as the computer, it is essential to the operation of the computer.

Each of these items of transcription equipment is usually supplemented by an appropriate 'verifier' which serves to minimize errors. Verifiers are recommended for any computing center.

In recent years, punched card input to computers has been the type most frequently used. The keypunches, the card verifiers, and the cards are relatively inexpensive, versatile, and easy to use. Moreover, correction is easy if the error is on a card rather than on a long reel of either perforated or magnetized tape.

The output of the computer may come in a variety of forms, and a choice is often given to the user in order to

facilitate future work with the results obtained. Punched card output, for instance, may be desirable if the results are to be used again in a later run or by a different piece of equipment. The same is true for magnetic tape output. Paper tape output may also be desirable—for example, in the case of special laboratory or shop equipment which is controlled by such tape.

As far as the general user is concerned, the most readily understood output is of course the printed page as it comes, for example, from modern high-speed printers. In small and medium size computer systems, these printers are directly attached to the main frame. In large-scale systems, they (as well as most of the other input/output devices) are usually controlled by a small separate computer which communicates with the large computer only via magnetic tape.

Annual service contracts may be negotiated with most manufacturers for the maintenance of their products. It is also possible to have one's own staff of engineers for maintenance although this is not normally advisable, unless there are special personnel resources. In either case, these costs must be provided for in the annual budget.

Since computer equipment does not deteriorate too much with time, provided it is properly maintained, it should be possible to base choices of new or used equipment upon design characteristics and not so much on date of manufacture. Yet the rapidity of advances in computer technology is causing computer equipment to become obsolete within relatively few years. The manufacturer may no longer maintain obsolete equipment, and maintenance by a staff of engineers at the university may require costly stocking of large sets of spare parts.

To date, there is no standard answer to the problem whether to choose new or used equipment. Likewise, there is no straightforward formula which one may apply to determine whether to rent or to purchase the equipment. Each school must carefully weigh the advantages of one method of financing over the others in terms of the prospects for financial support.

Two general points, however, should be made here: it is very important to select a computer system which can later be expanded since it is an almost invariable rule that demands on university computers increase at a very rapid rate. And, except in the case of very strong institutions with sufficient staff and resources, which can afford the expensive role of pioneer, it is very desirable to select a computer of a type used in at least a few other institutions so that valuable programs and other technical know-how can be shared.

THE PROGRAM LIBRARY

The importance of the computer program library, frequently spoken of as the 'software,' cannot be over-emphasized. Without an adequate program library, the computer hardware can be used only by persons well acquainted with programming. Moreover, only in special cases can an institution hope to have a sufficiently large and skilled programming staff to build and maintain by itself a good program library and at the same time to keep up with the usual daily programming requirements.

A good program library contains not only a well assorted set of special-purpose programs (such as those for performing the standard statistical computations) and a well written set of mathematical subroutines (such as those for computing the elementary functions — square root, sine, cosine, etc.), but also even more important programs for simplifying the programming process itself

and for monitoring the execution of the program on the computer.

The machine language of computers is in most cases extremely difficult and tedious to use. Special programs have therefore been written for every modern computer which simplify this programming task in a variety of ways and which make the programming language easier to understand, to learn, and to use. The computer is then used to translate these languages into its own machine language. Some translation programs such as those for the widely used languages FORTRAN, COBOL, ALGOL, etc., are usually furnished by the computer manufacturer. Other translation programs for less general languages to be used with the specific computer should also be part of the manufacturer's software package together with the standard subroutines for mathematical functions mentioned earlier.

For large computers, executive 'monitor' programs should be available to supervise a part of the execution: in particular, to handle many jobs consecutively without operator interference and at the same time to record automatically the time used for each program and to perform other operational and bookkeeping tasks.

The annual budget of even a small computing center should include the salary of at least one person whose sole task it is to build and maintain the program library. This task includes documenting new programs, revising old ones, finding errors that may still be inherent in programs received from elsewhere, and making sure that there are adequate descriptions for the user of all library programs.

Most manufacturers offer free pre-installation checkout time on a computer of the ordered type. This time is offered to give the customer the opportunity to check out

the programs fundamentally important for his program library and to gain some experience with their use.

In conclusion, it should be said again that sales representatives from manufacturers are primarily salesmen. The advice of experienced computer scientists should be obtained on both the appropriateness of the hardware and on the adequacy of the software support offered by any manufacturer.

SPACE REQUIREMENTS AND LOCATION OF COMPUTING CENTERS

The space requirements and the location of a computing center on a campus are determined by a number of factors. The most obvious of these are the size of the contemplated computer and the availability of space and funds to remodel a structure or build a new one to house the center. The rules which apply in any department with respect to proper offices, sufficient classrooms, etc., also apply in a computing center; but, in addition, the interdisciplinary nature of computing makes the accessibility of the center a major consideration. Moreover, computing is a rapidly changing and growing field. Experience on numerous campuses has shown that computing centers tend to expand much more rapidly than most other departments. Therefore, over-all planning for the future is particularly important; for the expansion of computer facilities tends to impose special problems, such as the expansion of air conditioning, electrical power supplies, computer and supply space, and so on.

SPACE REQUIREMENTS

The most important room in a computing center is, of course, the computer room itself. Depending on the size and type of computer, this room must have special air conditioning and meet the proper electric power requirements. For larger computers, false flooring may be necessary in order to place the connecting cables beneath the floor. Adjacent to the computer room, air-conditioned storage areas must be available for supplies. It is often desirable to provide a special area where visitors can observe the activities without interfering with them.

In addition to the main computer room, space is needed for such peripheral equipment as keypunches and sorters. There is also need for appropriate data preparation and ready rooms with card files and table space for the preparation of programs. Special rooms which may be used for quiet work on programs are desirable. Since part of the work is consulting and advisement, there must be areas where staff and users can meet for discussion. To facilitate instruction, adequate classroom space must be available. Since part of the work is research and part is keeping up with developments in the computer sciences, both a program library and a small traditional reference library are needed. And there must also be adequate offices for the staff of the center, arranged to insure working privacy.

Not all of these rooms are necessary for every computing center. Smaller centers may work adequately with only a few special rooms. The possibility of future expansion of the entire space allocated to the center is, however, of prime importance.

ACCESSIBILITY

The extent to which a computing facility will be used

by faculty and students depends critically on the location of the center on the campus. Ideally, a computing center should be located centrally with respect to users from all departments. In this respect, the computing center is like the main library. In the case of the large campus where no given location is uniformly accessible to all potential users, the center should provide convenient parking space for users.

Access may also be provided by setting up special delivery services, and remote consoles or input/output units may be located at a number of places on the campus for use in connection with at least the larger centers. In some cases, it may be desirable to establish liaison offices remote from the center where computer specialists can meet at regular hours for consultation with faculty and students.

STAFF REQUIREMENTS

No university should plan a computing center without making adequate provisions for a competent director and a suitable staff. The staff requirements vary radically with the nature and complexity of the computing services to be performed by the center. There are successful university computing center directors from almost all of the academic disciplines; but it is essential that the director should appreciate the full scope of the service to instructional, research, and administrative functions of the university which the center can render. He should be willing to cooperate with people from all phases of university life from beginning students to the most senior of department heads and the business office.

A natural choice as to the subject matter field of a director would be the field most active in computation at the university at the time of installing the center. There are dangers, however, in choosing a director on this basis

unless he is fully aware of the possibilities of computing and data processing for the university as a whole including departments which have not begun to exploit the computer in their research and teaching. He should be willing to cultivate interest in computing in areas which should be making use of the computing center but might not do so unless encouraged and trained.

It is frequently convenient to classify university computing centers in a manner indicating the size of the operation and the appropriate staff. College and university computing centers tend to fall into the categories listed below:

1. A small computer with part-time staff. This is the minimum operation to be considered a computing *center*, that is, as a facility serving interdepartmental functions.

2. A medium computer with a small full-time staff. Here the emphasis will probably be on service to undergraduate teaching.

3. A medium to large computer with professional staff engaged in its own undergraduate or graduate teaching, in consulting services to research in other departments, and in research in computer science.

4. A large to super computer with professional staff

engaged in research in all areas of computer science, including both computer utilization and computer design, as well as the functions mentioned above.

Regardless of the size of the installation, it is essential that, once a suitable director is chosen, he be provided with adequate clerical and technical staff from stable university funds. The size of staff will depend upon the scope of the activities which the center is expected to perform. Types of personnel required in a large university computing center include programmers, both in compiler and in machine language; systems analysts; programming analysts; machine room supervisors; operators for the computers and for the peripheral equipment such as keypunch, sorting, or collating machines; consultants to work with users having research or instructional programs of their own for use in classes or personal research projects; instructors in programming; and student assistants for grading papers connected with programming and for helping student programmers. In smaller centers, all these functions may be required; but it is frequently possible for a single individual to serve in many of the capacities mentioned.

Included within a staff of any size must be personnel who can organize and use the program library and responsibly operate the computing equipment.

Once a key permanent staff is made available from university budget sources, additional part-time help can frequently be obtained. Student assistants who become familiar with programming and with operating the computer may be employed for clerical work and for some of the programming and analysis.

Many universities may find it very difficult to compete with industrial computer organizations for able personnel

needed to fill some of the positions listed. For this reason, the university may need to rely on employing able and mature undergraduate and graduate students to carry on part of the work.

THE ADMINISTRATION AND FINANCING OF A UNIVERSITY COMPUTING CENTER

The administrative position of a computing center within a college or university will necessarily vary with the individual school. It will depend on existing administrative traditions and on such factors as the special academic interests of the institution. Here, therefore, only rather general guidelines for the administration and financing of a center will be offered. They are based on the premise that the institution accepts the high-speed computing equipment as an essential part of its educational and research facilities and that the computer's primary function, accordingly, is to improve and develop instruction and research. The guidelines are as follows:

1. The computing center should be recognized as being properly an interdisciplinary and interschool facility, in some ways similar to the library, and should be administered so that all qualified faculty members, administrators, and students have convenient access to the computing facility. Convenience here refers both to the location of the center and to the administrative arrangements for its use.

2. Since the center's most significant activities are of an educational or research nature, the director should have

an academic appointment in the university and report to an appropriate academic authority, e. g., the vice president for academic affairs, the dean of the graduate school, or the provost and not to a purely administrative authority such as the registrar or the comptroller.

3. The center should be an administrative entity with its own separate budget allocation; and the director should have adequate authority, similar to that of a department chairman or dean, to handle all internal administrative and academic affairs of the center, subject only to the usual general policies in force at the institution.

4. Because of the university-wide activity of a computing center, it may be desirable to establish an interdisciplinary advisory committee to advise on the policies governing the center. The members should be professional persons who are well acquainted with the computing requirements of the university and who will represent the best interests of the institution in a responsible manner.

The foregoing recommendations reflect the conclusions of the conference of university computing center directors sponsored by the National Science Foundation in Chicago, June 2-4, 1960; and they are based on experience during operation of all types of college and university computing centers over a period of many years.

In the light of the recommendations concerning the administrative position of the center within the academic framework of the institution, it is apparent that the financial support of the center should be the responsibility of the central administration of the institution. The computing center, as recommended above, should be a separately budgeted entity. The budget allocation should be sufficient to support the basic operating costs and to enable

the center to carry on its educational and research activities without relying on income from outside sources.

The best way to support the computing center is to provide directly through the university budget the money necessary for successful operation. Special aid, however, is usually necessary to meet the initial cost of establishing a center and for subsequent expansions. But financial aid should not be accepted under conditions which will prevent the computing center from supplying adequate services to instruction and unsubsidized research.

Partial support for the center may, of course, be obtained through special grants by industry or government. Great care should be exercised in the case of grants from government agencies. Changes in regulations governing the use of such grant money may be made on short notice. Since state-supported institutions often operate on budgets determined in advance for a biennium, reliance on grant money without adequate direct budget support can cause serious problems for a computing center if grant renewals are delayed or denied.

Many schools also provide partial support for the computing center by making charges for services both to users from outside the institution and to departments or research projects within the institution. In case of externally supported research, this is a necessary device for obtaining funds actually intended for computing services by the sponsors of the research. In the case of computing services rendered to projects supported by local university budgets, however, the increased bookkeeping costs for internal transfer of funds are so high and the amounts involved so difficult to estimate adequately for budget-building purposes that a more satisfactory arrangement is to support all services provided to intramural projects by direct allocation of university funds to the center. Here again one may draw the analogy between the services provided by the computing center and those provided by the library. Certainly, few libraries could operate successfully if their budgets had to come in fragmentary fashion from the budget of individual departments and users.

Whatever the sources of funds for the establishment and operation of the computing center, one primary consideration should hold: any support is acceptable which does not interfere with the proper use of the center for research and instructional purposes of the university.

In one important respect, the problems of financial support for a college or university computing center differ from those of other academic departments. For when a computing center is organized, staffed, and equipped in a progressive school, utilization increases almost invariably at such a rate in the early years of operation that staff requirements and machine costs, including the acquisition of bigger and more powerful machines and additional space, grow very rapidly. Budget needs therefore increase much faster than budget growth normally expected on the academic scene. This probability should be taken into account in the budgetary planning for computing centers.